(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : 0 249 871 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication of patent specification : 26.04.95 Bulletin 95/17

(51) Int. Cl.[6] : G06M 7/00, G06M 7/10, G06M 7/06

(21) Application number : 87108383.8

(22) Date of filing : 10.06.87

(54) **Method and apparatus for detecting and counting articles.**

(30) Priority : 20.06.86 US 876486

(43) Date of publication of application : 23.12.87 Bulletin 87/52

(45) Publication of the grant of the patent : 26.04.95 Bulletin 95/17

(84) Designated Contracting States : CH DE FR GB IT LI NL SE

(56) References cited :
EP-A- 0 049 681
GB-A- 2 011 613
US-A- 3 543 930
US-A- 3 589 599
US-A- 3 813 522

(73) Proprietor : EDS Technologies, Inc.
3200 West 84th Street
Hialeah Florida 33012 (US)

(72) Inventor : Watts, Leonard A.
3797 N.E. 167th Street
North Miami Beach Florida 33160 (US)
Inventor : Johnson, William A.
463 Hanlon Road
Holliston Massachusetts 01746 (US)
Inventor : Sawabini, Charles E.
1800 Commonwealth Avenue
Brighton Massachusetts 02135 (US)

(74) Representative : Patentanwälte Grünecker, Kinkeldey, Stockmair & Partner
Maximilianstrasse 58
D-80538 München (DE)

EP 0 249 871 B1

Jouve, 18, rue Saint-Denis, 75001 PARIS

Description

The invention relates to a method and apparatus for counting articles as indicated in the precharacterizing parts of claims 1 and 24.

Modern day manufacturing plants, process, treat, inspect, segregate, transport and otherwise handle articles or objects at extremely high speeds. Many such applications require the reliable detection and counting of relatively fast moving objects. For example, newspaper publishing plants typically deliver signatures to the mail room at the rate of 80,000 per hour or more, for purposes of being formed into signature bundles of an accurate, predetermined count, which bundles are then wrapped or tied and delivered to various locations for sale or subsequent delivery. Many of the articles have distinctive profiles that may be used for detection purposes. In the present example, the signatures are typically delivered in an overlapping stream with folded edges forward. The folded forward edges have typically been utilized for counting and stacking purposes. Counters of the mechanical or optical type are employed for counting articles, such as signatures in the stream by simply and accurately identifying the passage of the folded forward edge or the nose of a signature. However, mechanical signature counters have the disadvantage of wearing after prolonged use. Optical systems have become degraded due to the accumulation of dust or dirt on the optical components.

It is therefore desirable to provide a method and apparatus for detecting and counting which does not experience wearing suffered by mechanical counter and/or which becomes degrade due to accumulation of foreign matter upon the sensing elements as is the case with counters of the optical type.

A prior art apparatus as indicated in the precharacterizing part of claim 1 is disclosed in US-A-3,813,522. In this prior art, the sensing means uses an air jet which creates a low pressure signal within a tube for transmitting pressurized air. The signal has a frequency characteristic which may be varied by the passage of the articles to be counted. Pressure variations within the tube are sensed by an audio-responsive sensing element, for example, a carbon microphone which is mounted in a bore which is provided at the upper end of the tube transmitting the pressurized air jet toward the conveyed articles to be counted. The sensing element senses either a shift in frequency or a change in amplitude of the air pressure reflected by the articles.

In another prior art apparatus as disclosed in US-A-3,589,599, sheets of paper, cardboard or the like material are counted when feeding successive sheets along a line of movement in overlapped condition. The apparatus comprises an air jet nozzle directing an air jet at an oblique angle to the feeding direction of the sheets. Associated with the air jet nozzle is a device which measures the pressure differences arising during the passage of frontal or leading sheet edges through the path of the air jet. The measured pressure differences are converted into electrical pulses for actuating counting means.

It is the object of the invention to provide an improved method and apparatus for detecting and counting signatures capable of discriminating between distinctive profiles of the articles.

This object is solved by the features as claimed in the characterizing parts of claims 1 and 24.

In accordance with the invention, a signal is generated which varies in accordance with the sound waves generated by the interaction; and the articles are counted in accordance with the variations of amplitude in a signal which is generated by selecting a plurality of frequencies corresponding to frequencies of the sensed interaction wherein the amplitude of said generated signal varies with the amplitudes of the selected frequencies.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1, 1b and 1c respectively show side and end views of a sensor head assembly designed in accordance with the preferred embodiments of the invention.

Figure 2 shows a simplified block diagram of the elctrical system utilized for analyzing the acoustic signal detected by the sensor of Figures 1a to 1c, in accordance with a preferred embodiment of the invention.

Figures 3a and 3b show portions of the block diagram of Figure 2 in greater detail and in schematic form.

Figure 4 shows a simplified block diagram of the post front end processing circuit for processing the signals developed by the front end circuit of Figure 2, in accordance with a preferred embodiment of the present invention;

Figure 5 shows a detailed schematic diagram of the post front end processing circuit of Figure 4;

Figure 6 shows a block diagram of an another preferred embodiment of a processing circuit of the present invention; and

Figures 7a, 7b and 7c show a signature stream and waveforms useful in describing the operation of the preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figures 1a to 1c show side and end views of a sensor head assembly 20 embodying the principles of the present invention. The sensor head assembly is utilized within a conveyor system comprised of a plurality of top belts 11 and 12 engaging rollers 13 and 14 only portions of which have been shown in Figure 1a

for purposes of simplicity.

Bottom belts 15 and 16 cooperate with top belts 11 and 12 respectively for receiving signatures therebetween and advancing said signatures to a utilization device. It should be understood that the conveyor arrangement of Figure la is highly simplified, such conveyor arrangements being well known in the art. The sensor assembly 20 of the present invention is typically arranged within the infeed section of a signature stacker having cooperating sets of top and bottom belts for receiving the signatures from a press conveyor and delivering the signatures toward the signature supports of a stacking section in the stack for accumulating a predetermined number of signatures for each stack. It should be understood that the sensor assembly of the present invention may be employed in other types of signature stacker and/or any processing or conveying apparatus, or signature conveying means, in which it is desired to sense and/or count signatures as the case may be.

The sensor assembly 20 is positioned between the facing inner ends 13a and 14a of rollers 13 and 14 and is comprised of a substantially L-shaped bracket 21 having a horizontally aligned arm 21a secured to a stationary member F by fasteners 22, said support member F being secured to or forming part of the main frame of the signature stacker or other signature conveyor means.

A supporting block 22 is secured to the lower end of downwardly depending arm 21b by suitably fastening means (not shown) and has a substantially J-shaped configuration when viewed as shown in Figure 1b. A narrow elongated horizontally aligned bore 23a communicates with an L-shaped coupling 24 having its left-hand end secured to the right-hand end of bore 23a for coupling a regulated air supply to bore 23a by way of air supply conduit 24a which is retained against the right side of arm 21b by hold-down clamps 24b.

A diagonally aligned short bore portion 23b in block 23 communicates with bore 23a and is adapted to receive a nozzle 25 fitted into large diameter bore 23c which communicates with bore 23b. The nozzle 25 is arranged so that its center line, represented by phantom line 26 shown in Figure 1a, is diagonally aligned relative to the horizontal direction, i.e. relative to top and bottom belts 11, 12 and 15, 16. In the preferred embodiment, the longitudinal axis 26 of the nozzle forms an angle of the order of 25 degrees with the vertical.

A plurality of microphones 27, 28, 29 and 30 are arranged to lie upon an imaginary circle at equispaced intervals about nozzle 25 as shown best in Figure Ic and are electrically coupled into the processing circuitry, as will be more fully described. The use of four microphones enhances the directional characteristics and hence the sensitivity of the sensor head to the detection of signautes as opposed to ambient noise. Channels 23d and 23e in block 23 are provided for receiving the electrical wiring 32, 33 utilized for electrically connecting the microphones 27 through 30 with the processing circuitry. These channels are preferably covered with a suitable sealing material after assembly. The electrical wires 32 and 33 extend upwardly through a diagonally aligned wiring duct 23f which communicates with a horizontally aligned wiring duct 23g which in turn communicates with a vertically aligned wiring duct 23h whose upper end receives an electrical connector 34 secured to an upper face of support 23 by fasteners 35. A cooperating coupling connector (not shown for purposes of simplicity) electrically couples the microphones 27 through 30 through wiring 36 for connection with the processing circuitry which is preferably located remote from the signature conveyor of Figure 1a.

In order to enhance the effectiveness of sensor head 20 and reduce the effect of ambient noise, the hollow interior of rollers 13 and 14 are filled at their ends 13a and 14a with a suitable acoustic dampening material as shown in dotted fashion at 37 and 38.

The diagonal alignment of the pressurized air stream developed by nozzle 25 prevents the air stream from striking the bottom belts, such as, for example, belt 16, in the absence of a signature stream in order to prevent the interaction of the air stream with the bottom belt from being erroneously detected as indicated a "paper" state.

The bottom surface of the support member 23 is provided with diaonally aligned trailing and leading surfaces. The leading surface 23j (note the direction of stream flow shown in Figure 1b) guides the signatures beneath the bottom surface 23k, through which the pressurized air stream exists.

As was mentioned hereinabove, and as will be described in further detailed hereinbelow, the microphones are arranged as an array physically. Physically, the microphones 27, 29 are located along an imaginary diameter as are the microphones 28, 30. All of the microphones 27 through 30 arranged at equispaced intervals about an imaginary circle whose center coincides with the longitudinal axis 26 of nozzle 25.

In the actual reduction to practice of the described embodiment, favorable results were achieved with the following parameters. In order to reduce "self noise", i.e. the noise created by pressurized air passing through the nozzle with no paper present, the bore length of the nozzle is selected to be between 1.25 and 2.54 cm (0.5 and 1 inches) and is preferably a length of the order of 2.3 cm (0.9 inches). The bore diameter lies in a range from 0.08 to 0.13 cm (.03 to .05 inches) and is preferably of the order of 0.11 cm (0.042 inches).

The nozzle pressure has been selected to be of a pressure magnitude sufficient to provide an adquate acoustic signal and yet not too large in magni-

tude as to create high nozzle "self moise". The pressure range lies between 1,4 and 3,5 bar (20 and 50 psi) and preferably in the range from 2,1 to 2,8 bar (30 to 40 psi). The separation between the nozzle and the signature surface is preferably selected to avoid excessively strong reflection of the pressurized air stream off the paper which makes it difficult to detect edges and also to prevent generation of a signal which is too weak to reflect off the paper causing the "paper" condition appear to be very similar to the "space" condition i.e. the condition when no signatures are present. The spacing between the bottom surface 23k of block 23 and the top surface of the signature stream is preferably in the range from 0.64 to 3.8 cm (0.25 to 1.5 inches) with the preferred sensor to paper distance being of the order of 1.14 cm (0.45 inches) from the top surface of the signature to the surface 23k of block 23. The outlet end of nozzle 25 in the preferred embodiment is preferably substantially flush with surface 23k.

The range of paper speed over which the counter is capable of operating is from 0 to 137 m (450 feet) per minute. An increase in the delivery rate of the signature stream tends to reduce signal amplitude of the acoustic signal. Although the above parameters provide favorable results when detecting and counting signatures, it is anticipated that other parameters including nozzle dimension, pressure, and spacing may be required for other articles.

Figure 2 shows a simplified block diagram of the front end electronics 50 and is comprised, for exmaple, of microphones 27 and 29 electrically connected to summing circuit 53 by preamplifiers 51 and 52. It should be understood that the outputs of all four microphones 27 through 30 may be summed, the example given herein being merely for purposes of simplicity. The summed output is applied to gain control circuit 54 and limiter 55 for gain control, filtering and limiting. The output of limiter 55 is applied to automatic gain control circuit 56 for regulating the gain of gain control amplifier stage 54. The output of limiter 55 is coupled in common to an eight (8) band spectral analyzer 57 each band 58 through 65 respectively containing a band pass filter 58a through 65a and an RMS-DC converter circuit 58b through 65b.

The outputs of each of the bands 58 through 65 are coupled to a summing circuit 71 forming part of the post front end processing circuit 70 shown in block diagram form in Figure 4. The output of summing circuit 71 is coupled through amplifier 72 which amplifies the output of summing circuit 71 and couples the amplified output to three circuit paths 73a, 73b and 73c. The circuit path 73b couples the averaged signal to low-pass filter 74 for developing a signal at the output of filter 74 representative of the average paper level. The average paper level represents the signal level (i.e. "paper") when the portion of the signature between its leading and trailing edges is passing beneath the acoustic detector 27 through 30. The average paper level signal is applied to threshold generating stages 75 and 76 which develop "edge" and "space" threshold levels respectively, which levels are coupled to decision circuit 77 which is comprised of comparators as will be more fully described for dynamically determining the state of the signature stream, as will be more fully described.

Branch circuit path 73a contains a difference circuit 78 which receives the summed output of the spectral analyzer 57 and subtracts therefrom the average paper level. The difference is applied to rectifier circuit 79 and matched filter 80, the output signal of which is utilized by decision circuit 77 for comparison with the edge threshold level to detect the presence of edges.

Circuit path 73c couples the summed output from spectral analyzer 58 through matched filter 81 to apply a detected space signal to decision circuits 77 which compares the detected space signal with the space threshold level for detecting the presence of a space condition. The matched filters 80 and 81 are "matched" to low-pass filter 74 to match the transient response in each branch circuit 73a, 73b with the transient response in circuit branch 73b to assure that the signals being compared are substantially in time synchronism.

Rectifier 79 is a half-wave rectifier for passing only the upper half of the a.c. type signals. The matched filters filter out signals which are shorter than one millisecond while passing the edge signals.

The operation of the apparatus shown in Figures 2 and 4 will now be considered in conjunction with the diagrams shown in Figures 7a, 7b and 7c.

Nozzle 25 (see Figure 1a) emits a jet of compressed air to generate a distinct sound as the edge of a newspaper (Figure 7a) passes through the air jet. Microphones 27 through 30 are strategically arranged to allow the acoustic signal to be detected (preferably to the exclusion of ambient noise) and processed.

The nozzle/microphone sensor head 20 detects not only the leading edges L of signatures S (Fig. 7a), but detects the trailing edges T of the signatures when gaps G appear in the signature stream. Since the sound produced by a trailing edge is not radically different from the sound produced by a leading edge, the detector/counter system is provided with additional intelligence for differentiating between leading (typically "folded") and trailing (typically "out") edges of signatures.

The technique employed in the system of the present invention initially defines three states which can exist in the region of nozzle 25. The first stage is the "space" state which exists when no paper is present beneath the nozzle. This state produces the weakest signal at microphones 27 through 30 since no paper is present to reflect compressed air back to-

ward the microphones 27 through 30, the pressurized jet of air being arranged to avoid striking and thus being reflected from either the top belts 11, 12 or the bottom belts 15, 16.

The second state is the "edge" state where the edge encountered (either the leading or trailing edge) is interrupting the jet of compressed air. This state produces the strongest signal at the microphones 27 through 30.

The final state is the "paper" state which exists when the portion of the signature between its leading and trailing edge is passing beneath the nozzle and is interrupting the pressurized air stream.

The counter system of the present invention examines the processed signals from the microphones 27 through 30 and determines the current nozzle state ("space", "edge" or "paper"). Knowledge of the current state plus the previous history allows the system to properly identify a single signature (space-edge-paper-edge-space); multiple overlapping signatures (space-edge-paper-edge-paper-...); and certain types of false triggers (e.g., space-edge-space). The intelligence is embodied in the state determining circuitry shown in Figure 4. The output of this circuitry develops a pulse per valid leading edge which is passed, for example, to a counter 82 (see Figure 4) to tally the number of papers. The signal may also be employed to activate stacker apparatus, if desired.

The signals detected by microphones 27 through 30 undergo amplification by preamplifiers 51 and 52 (Fig. 2). The signals are mixed at 53 and undergo gain control amplification at 54 and are then coupled to limiter circuit 55. Limiter 55 further includes filtering means to reduce out-of-band noise, providing rolloff below 200 Hz and roll off above 27 kHz, in the preferred embodiment. This filtering can be accomplished at both the input stage and mixer gain stage as will be more fully described in conjunction with the description of Figures 3a and 3b.

The output from limiter 55 is applied to spectral analyzer 57 which, in the preferred embodiment is an eight band 1/2-octave real-time spectral analyzer. Each band passes frequencies within its respective one-half octave range by filters 58a through 65a and thereafter performs a detection operation by way of RMS/DC converter 58b through 65b. The signals developed by each of the eight bands are summed by summing circuit 71 which acts to average the results. A form of majority-vote action results, since noise present in only one of the bands 58 through 65 is reduced by the averaging operation.

The output from summer 71 (Figure 4) after voltage amplification, is applied to low pass filter 74 which, in the preferred embodiment, is a 0.1 Hz low-pass filter for extracting the level associated with the nozzle "paper" condition described hereinabove. The thresholds for the "space" and "edge" conditions are then set proportional to the average "paper" level, allowing the processing circuitry of Figure 4 to track the actual received signal level.

Electrical circuit path 73c couples the output of the summing circuit 71 to comparator circuit 77 for comparison with the derived space threshold employing suitable comparator means forming part of decision circuit 71 as will be described in greater detail hereinbelow. If the signal level in circuit path 73 drops below the space threshold, the space condition is detected. Matched filter 81 matches the transient response in circuit path 73c with the transient response in circuit path 73b.

The third electrical path 73a is employed to detect the edge condition. Although circuit path 73a could employ the same circuitry employed in circuit path 73c (i.e. only matched filter 80), improved performance can be obtained by utilizing the detected paper level derived from the output of low pass filter 74 to provide an offset which is subtracted from the output of summing circuit 71 by difference circuit 78, which step occurs prior to edge detection. The difference signal developed at the output of difference circuit 78 is rectified at 79 to pass only the upper half of the a.c. type signal and than passes through matched filter 80 which couples the signal to an associated input of decision circuit 77. If the signal in circuit path 73a is greater than the threshold level representing an edge condition, an edge state signal is generated.

To reduce "self noise", i.e. noise created by the pressurized air passing through nozzle 25 with no signatures present, the nozzle bore length is adjusted to lie within the range from 0.76 to 3.81 cm (0.3 to 1.5 inches) and prefereably of the order of 2.29 cm (0.9 inches). The bore diameter is chosen to be within the range from 0.081 to 0.132 cm (0.032 to 0.052 inches) and preferably of order of 0.11 cm (0.042 inches) to further optimize the reduction in self noise.

System sensitivity is enhanced by selecting nozzle pressure so that it is not so low as to cause too small a signal at the microphones and thus have low immunity from ambient noise and not so high as to generate and undesirable level of self noise. The optimal pressure range is between 17.6 to 31.6 bar (25 and 45 psi) and preferably of the order of 21 to 28 bar (30 to 40 psi).

The separation distance between the bottom surface 23k of block 23 and the adjacent (top) surface of the signatures is preferably chosen so as not to be too small to result in an excessively strong reflection of the air stream off of the signature surface making edges difficult to detect. On the other hand, a separation distance which is too large results in a correspondingly weak reflection of the air stream off the signature, creating a paper condition similar to the space condition and further contributing to the difficulty to detect edges. The optimal sensor to paper distance is of the order of 0.76 to 1.52 cm (0.3 to 0.6 inches) and is preferably of the order of 1.14 cm (0.45

inches). The exit orifice of nozzle 25 is preferably flush with surface 23k. The nozzle 25 is retained in bore 23c by means of a toroidal-shaped member 25a whose upper end engages a flange on nozzle 25 and whose lower end threadedly engages the tapped lower end of bore 23c.

Figure 5 shows a detailed schematic diagram of the post front end processing circuit of Figure 4, summing circuit 71 being comprised of matched resistors R1 through R8 having their left-hand ends coupled to the output of the respective bands 58 through 65 of spectral analyzer 57 and having their right-hand ends connected in common to the inverting input of operational amplifier 71a. The output of the summer circuit 70 is coupled to the three branch circuits 73a, 73b and 73c through amplifier stage 72. Low-pass filter 74 is comprised of operational amplifier 74a, capacitor C1 and C2 and resistors R9 and R10. The output of low-pass filter 74 is applied to edge threshold generating circuit 75 including operational amplifier 75a, resistors R11 and R12 and adjustable resistance R13. A portion of the average paper level signal is applied to the non-inverting input of operational amplifier 75a whose gain is determined by the value of resistors R11 and R12 to develop an edge threshold signal.

The space threshold generating circuit 76 comprises operational amplifier 76a and adjustable resistance R14.

The decision circuit 77 comprises comparators 77a and 77b, the inverting inputs of comparator 77a and 77b being coupled to branch circuits 73a and 73c respectively while the non-inverting inputs receive the threshold levels from circuit 75 and 76. The outputs of comparators 77a and 77b are coupled in common to output terminal 84 through diodes D1 and D2 and resistors R15 and R16 whose right-hand terminals are connected in common terminal 84 which is coupled to +VDC through resistor R23.

Considering branch circuit 73a, difference circuit 78 comprises operational amplifier 78a having its inverting input coupled to the output of low-pass filter 74 by resistor R24, and its non-inverting input coupled to the summing circuit 70.

Rectifier 79 is comprised of operational amplifier 79a, diodes D3 and D4, resistors 28 through 31 and operational amplifier 79b, forming a half-wave rectifier for passing only the upper half of the acoustic signals. Matched filter 80 is comprised of operational amplifier 80a, resistors R32 and R33 and capacitors C3 and C4.

The matched filter 81 in branch circuit 73c comprises operational amplifier 81, resistors R34 and R35 and capacitors C5 and C6. The matched filters are utilized to match the transient response in circuit branches 73a and 73c with that in branch 73b as was previously described.

Figure 3a shows a schematic diagram of the front end electronics in which the preamplifier stages 51 and 52, employing transistors Q1 and Q2 each of which develop an output signal at adjustable potentiometers P1 and P2 which are applied through operational amplifiers 92 and 93 to the mixer circuit 53 including operational amplifier 53a and an adjustable gain control circuit comprising feedback resistor/capacitor pairs C14, R18 through C11, R15 selectively coupled into the feedback circuit through the switch arms K1a through K3a of coils K1 through K3, respectively. The gain is adjusted by a gain control circuit (not shown in fig. 3a for purposes of simplicity) for adjusting the gain in accordance with the level of the signal developed by limiter 55.

The limiter 55 comprises a low-pass filter section and a limiter with peak indication. The low-pass filter section eliminates signals at the upper end of the frequency band and, in one preferred embodiment, has a three db down point of the order of 16kHz. The limiter section clips signals greater in magnitude than a predetermined voltage level which, in the embodiment shown is of the order of ≡ 4 volts DC.

Figure 3b shows on typical detector section such as, for example, section 58 shown in Figure 2, all remaining sections being substantially the same in design and function with the difference between the eight sections being that each band is operated to pass a different one-half octave band. The detector section 58 is comprised of a band-pass filter of the four-pole Chebychev type. The signal from the limiter circuit of Figure 3a, appearing at output line VSIG, is coupled to the inpus terminal INNA of a type LTC1060CN switched-capacitor filter circuit manufactured by Linear Technology. This chip operates as a commutating capacitor type filter operating at a frequency determined by the clock input applied in common to chip inputs CKA and CRB coupled to the clock input terminal labelled "Clock". The clock input coupled to the LTC1060CN chip in detector section 59 is coupled to one of the outputs of a clock generator 100 coupled to oscillator 101 which, in the preferred embodiment operates at a frequency of 10MHz. Clock generator 100 generates signals at its eight outputs f_1 through f_8 at frequencies which, in the preferred embodiment are chosen to pass an output frequency in which detection stage which is a fraction of the clock frequency. In one preferred embodiment, the one-half octave frequencies are 803Hz; 1.14khz; 1.61 khz 2.27khz; 3.21khz; 4.56khz; 6.43khz; and 9.10khz, although other bands may be employed if desired. For example, the number of bands may be increased to extend the range of 15 KHz or the lower bands may be limited and replaced by higher one-half octave bands. The clock signal provided at the input of each detector when divided by 50, yields the desired output. The signal, after undergoing amplification at stage 102 of detector 59 and after a gain calibration at potentiometer P3, is applied to an RMS/DC converter which may, for example, be a model AD636JH

RMS/DC converter for converting the AC signal to a DC signal, which converted signal is summed by summing circuit 71 shown in Figure 4, for example. As was mentioned hereinabove, each detector section is substantially similar in design with the difference being the frequency of the signal applied to the band pass filter chip by the clock generator.

Figure 6 shows another alternative embodiment of the present invention wherein like elements as betwen Figures 2 and 7 are designated by like numerals. In the embodiment of Figure 6, the outputs of the detectors 58a through 65a in the bands 58 through 65 are coupled to individual comparators 58c through 65c which receive threshold signals from adaptive threshold control circuit 104 to apply the paper input condition to each one of the eight inputs of majority (voting) logic circuit 105. The paper state condition is applied to the characteristic aquisition circuit 106 together with the outputs of each band 58 through 65, the state determined by the majority logic circuit 105, together with the output of each detector section, being utilized by circuit 106 to adjust the "edge" and "space" threshold levels generated by circuit 104, which threshold levels are applied to the comparators 58c through 65c. The paper state is determined by circuit 107 which may for example be similar to the circuit 77 shown in Figure 5. The paper state signal is applied to an I/O processor 108 which is selectively coupled to serial and parallel lines 109 and 110, display 111 and keyboard 112 by interfaces 109a through 112a respectively.

Since the 0.1Hz low pass filter employed in the post front end processing circuit shown in Figure 5 requires at least a short interval of time, typically in the order of ten seconds or so, to arrive at what may be considered to be a "steady state" condition, the output from the low pass filter 74 may be applied to an A to D converter 113 and stored in digital form in a memory device 114 (Figure 5). This "remembered" paper value may be initially utilized during system start-up by selectively decoupling the filter 74 from circuits 75, 76 and 78 and applying the stored digital value to a digital to analog converter 115 and applying the output of the D to A converter 115 to the threshold generating circuits 75 and 76 and to the summing circuit 78 employed in circuit path 73a.

In summary the present preferred embodiment of the invention heretofore described in detail is exemplified by a signature counter which is employing a jet of pressurized air which is directed to one surface of the signature stream. The jet of air strikes the surface of the signature, generating signals of varying acoustical levels and frequency as a function of the profile of the signature passing through the jet of air.

Preferably, the acoustic signal generated by the interaction between the jet of pressurized air and the signature stream is detected by a plurality of microphones which convert the acoustic signal into an electrical signal whose amplitude and frequency are related to the amplitude and frequency of the acoustic signal.

The electrical signals generated by the microphones are preferably summed, amplified, limited and filtered to reduce out-of-band noise.

The signal is then applied to a multiple band spectral analyzer, each band preferably having a one-half octave bandwidth.

The outputs of the spectrum analyzer are summed to essentially average the results. Preferably, the summed value is then split into three paths, one of which includes a low pass filter for extracting a level associated with the "paper" condition, i.e. the condition which exists when the portion of a signature between its leading and trailing edges moves beneath the jet of pressurized air. Thresholds for determining the edge and space conditions are derived from the "paper" condition and set so as to be proportional to the "paper" level. The circuit has the ability to track the received acoustic signals.

The second electrical circuit may include a matched filter, which couples the averaged output to a comparator for comparison with the space threshold. If the averaged output drops below the threshold, a space condition is detected. The edge condition is detected through the use of a third path which applies the averaged output through a matched filter to comparator means. The matched filters assure that the transient response in the three electrical paths are matched to assure proper comparison.

The microphones utilized for converting the acoustical signal to electrical signals are preferably arranged as in an array which are diagonally opposite the air jet nozzle. The pressurized air may be provided by a remotely located air compressor and regulator.

The bore of the air jet nozzle preferably has a length which is chosen to reduce "self noise", i.e. the noise created by pressurized air passing through the nozzle when no papers are present. The pressure level is selected to reduce the effects of self noise and yet to provide a signal having a signal strength sufficient to provide adequate immunity from ambient noise. The separation distance between the nozzle and the paper surface is selected to prevent an excessively strong reflection of the air stream off the paper when located too close to the paper surface and to prevent the generation of a correspondingly weak signal when the separation is too large, making it difficult to differentiate between a "paper" condition and a "space" condition. The nozzle may be oriented to be diagonally aligned relative to the paper surface of the signature to prevent the air stream from being reflected from the lower guide belt, in the example, and thus being erroneously detected as a "paper" condition, and further, for reducing the noise generated due to the interaction between the air jet and the surface of the signatures.

The system may be an "analog" type or may employ microprocessor-based control means for performing some of the functions otherwise performed by dedicated hardware through the use of software techniques. For example, the "paper" value extracted from the low pass filter may be converted from analogue to digital form and stored in memory for use during initial start-up conditions to eliminate the time required for the low pass filter to stablize upon the initiation of a paper run. Thus, the initialized conditions may be utilized by the system processing circuitry during the time required by the "paper" state extraction circuit to reach the steady state condition.

Although the present preferred embodiment of the invention is described in detail in connection with detecting and counting signatures, it is intended that the method and system of the present invention may be used for sensing and counting other articles, as well.

Claims

1. An apparatus for counting articles conveyed in a first direction along a path comprising:
   means (25) for directing an air jet toward the articles in a second direction (26) at an angle to the first direction to interact with the individual articles in succession;
   sensing means (27,28,29,30) for sensing the interaction of the air jet with the articles by sensing sound waves having varying frequencies and associated amplitudes generated by the interacting air jet,
   means (57,70) responsive to the varying frequencies and associated amplitudes of the sensed sound waves for generating signals characterictic of the interaction with the articles, and counting means (82) responsive to said generated signals for counting the articles;
   characterized in that
   said directing means (25) directs said air jet at an oblique angle to the first direction and said means (57,70) responsive to the varying frequencies and associated amplitudes comprises a spectrum analyzer (57) for selecting a plurality of frequencies and for generating a signal having an amplitude which varies in accordance with the amplitude of the selected frequencies.

2. The apparatus of claim 1, wherein said sensing means (27...30) comprises a plurality of sensors positioned around said air jet (25), each sensor (27...30) generating an output signal having predetermined characteristics which vary in accordance with a frequency and assoicated amplitude of the generated sound waves.

3. The apparatus of claim 2, wherein said articles are signatures both overlapped and spaced.

4. The apparatus of claim 2, wherein said sensors (27...30) are arranged at intervals about an imaginary circle surrounding said air jet (25).

5. The apparatus of claim 2, wherein the air jet directing means (25) includes means for providing air pressure in the range of approximately 2,1 - 3,5 bar (30 - 50 psi).

6. The apparatus of claim 5, wherein the air pressure is of the order of 2,8 bar (40 psi).

7. The apparatus of claim 2, wherein the air jet directing means (25) comprises an exit nozzle having a bore coupled to a source of pressurized air and having a bore length approximately between 1 and 4.8 cm (0.4 and 1.9 inches).

8. The apparatus of claim 7, wherein bore length is of the order of 2.3 cm (0.9 inches).

9. The apparatus of claim 7, wherin said bore has a diameter in the range from approximately 0.08 - 0.15 cm (0.03 - 0.06 inches).

10. The apparatus of claim 9, wherein bore diameter is of the order of 0.11 cm (0.042 inches).

11. The apparatus of any one of claims 2 to 10, wherein said sensors (27...30) are acousto-electric sensors arranged about said air jet (25) in a manner to enhance directivity of said sensor means (27,...30), each sensor including means for generating an electic signal corresponding to said sound waves received by the sensor; and comprising:
    means (53) for summing the generated electric signal of said sensors (27,...30) for obtaining a first output signal;
    filter means (58,...65) coupled to said summing means (53) for filtering out unwanted frequencies in the first output signals of said summing means;
    a plurality of band pass channels (57) each being coupled to said filter means (58, ...65) for passing a predetermined frequency band, the frequency bands of each channel being different, and
    detection means (70) responsive to the frequency bands of said channels for generating a first detection signal representative of a particular characteristic in said sound waves.

12. The apparatus of claim 11, wherein said detection means (70) further comprises a second summing means (71) for summing the frequeny bands of said band pass channels (57) to obtain

a second output signal;
means (75) coupled to said summing means (71) for developing a predetermined threshold level, and
first comparator means (77) for comparing said threshold level with the second output signal from said second summing means (71) for generating said detection signal when the second output signal of said second summing menas (71) is of a predetermined value relative to said threshold level.

13. The apparatus of claim 12, further comprising:
second threshold generating means (76) coupled to said second summing means (71) for generating a second threshold level for detecting a second characteristic of said profile;
second comparator means (77) for comparing the output of said second summing means (71) with said second threshold level for generating a second etecting signal when the output of said second summing means (71) is of a predetermined value relative to said second threshold level.

14. The apparatus of claim 13, wherein said second threshold generating means (76) comprises low-pass filter means extracting a level from the output of said second summing means (71) representative of the second characteristic of said sound waves, and means coupled to sai low-pass filter means for producing said second threshold level.

15. The apparatus of claim 14, further comprising a branch path (73c) for coupling the output of said second summing means (71) to said second comparator means (77), said branch path having a matched filter (81) for matching a transient response in said branch path (73c) with a transient response of said low-pass filter means.

16. The apparatus of claim 15, further comprising a second branch path (73a) for coupling the output of said second summing means (71) to said second comparator means (77),
said second branch path (73a) including match filter means (80) for matching a transient response of said second branch to the transient response of said low-pass filter means.

17. The apparatus of claim 16, wherein said second branc path (73a) further comprises means (78) for subtracting an output of said low-pass filter means from said second summing means (71).

18. The apparatus of claims 17, wherein said second branch path (73a) further includes half wave rectifier means (79) for passing only signals of one polarity and means for converting said half-wave rectifier signals to a d.c. signal.

19. The apparatus of claim 11, wherein each said band pass channel (57) comprises a band pass filter (58a,...65a) differing from each adjacent band pass filter by one-half octave.

20. The apparatus of claim 19, wherein said band pass filter means (58a,...65a) comprises a switched capacitor filter means.

21. The apparatus of claim 11, wherein each band pass filter channel (57) comprises filter means (58a,...65a) for passing a predetermined frequency band and means (58b...65b) for converting said frequncey bands of said filter means to a d.c. signal.

22. The apparatus of claim 21, wherein said filter means (58a,...65a) comprises a four-pole Chebychev filter.

23. The apparatus of any one of the foregoing claims, wherein said means (57,70) for generating signals characteristic of the interaction with the articles are monitoring first ("space"), second ("edge"), and third ("paper") states of said articles.

24. A method for counting articles conveyed in a first direction along a path, comprising the steps of:
directing an air jet towards the articles in a second direction at an angle to the first direction to interact with the individual articles in succession,
sensing the interaction of the air jet with the articles by sensing sound waves having varying frequencies and associated amplitudes which are generated by the interacting air jet, generating signals characteristic of the interaction with the articles in response to the varying frequencies and associated amplitudes of the sensed sound waves, and
using said generated signals to count said articles;
characterized in that
said directing step directs the air jet at an oblique angle to the first direction;
and said generating step comprises
selecting a plurality of frequencies, corresponding to frequencies of the sensed interaction, with a spectrum analyzer (57) governed by said sensed interaction; and
generating a signal having an amplitude which varies in accordance with the amplitude of the selected frequencies.

25. The method of claim 24, further including the step

of positioning a plurality of sensors (27,...30) adjacent the path at intervals about an imaginary circles surrounding said air jet (25).

26. The method of claim 24 or 25, wherein said generated signals characteristic of the interaction with the articles are summed for counting said articles.

27. The method of one of claims 24 to 26, wherein said selected frequencies comprise sound waves having a frequency above 1000 Hz.

28. The method of one of claims 24, to 27, wherein first ("space"), second ("edge"), and third ("paper") states of said articles are monitored.

Patentansprüche

1. Vorrichtung zum Zählen von Gegenständen, die längs eines Pfades in einer ersten Richtung gefördert werden, mit:
einer Einrichtung (25) zum Richten eines Luftstroms auf die Gegenstände in einer zweiten Richtung (26) in einem Winkel zu der ersten Richtung, um mit den individuellen Gegenständen in Folge zusammenzuwirken;
einer Sensoreinrichtung (27, 28, 29, 30) zum Erfassen des Zusammenwirkens des Luftstroms mit den Gegenständen durch Erfassen von Schallwellen, die sich ändernde Frequenzen und zugeordnete Amplituden haben, die durch den zusammenwirkenden Luftstrom erzeugt werden;
einer Einrichtung (57, 70), die auf die sich ändernden Frequenzen und zugeordneten Amplituden der erfaßten Schallwellen anspricht, um Signale zu erzeugen, die kennzeichnend für das Zusammenwirken mit den Gegenständen sind, und
einer Zähleinrichtung (82), die auf die erzeugten Signale anspricht, um die Gegenstände zu zählen,
dadurch gekennzeichnet, daß
die Richteinrichtung (25) den Luftstrom in einem schiefen Winkel zur ersten Richtung richtet und die auf die sich ändernden Frequenzen und zugeordneten Amplituden ansprechende Einrichtung (57, 70) einen Spektralanalysierer (57) zum Auswählen einer Vielzahl von Frequenzen und zum Erzeugen eines Signals aufweist, das eine sich mit der Amplitude der ausgewählten Frequenzen ändernde Amplitude hat.

2. Vorrichtung nach Anspruch 1, wobei die Sensoreinrichtung (27...30) eine Vielzahl von Sensoren aufweist, die um den Luftstrom (25) herum angeordnet sind, wobei jeder Sensor 27...30) ein Ausgangssignal erzeugt, das vorbestimmte Eigenschaften hat, die sich nach Maßgabe mit einer Frequenz und einer zugeordneten Amplitude der erzeugten Schallwellen ändern.

3. Vorrichtung nach Anspruch 2, wobei die Gegenstände sich überlappende und beabstandete Schriftstücke sind.

4. Vorrichtung nach Anspruch 2, wobei die Sensoren (27...30) in Intervallen um einen imaginären Kreis angeordnet sind, der den Luftstrom (25) umgibt.

5. Vorrichtung nach Anspruch 2, wobei die den Luftstrom richtende Einrichtung (25) eine Einrichtung zum Erzeugen eines Luftdruckes im Bereich von etwa 2,1 bis 3,5 bar (30-50 psi) umfaßt.

6. Vorrichtung nach Anspruch 5, wobei der Luftdruck in der Größenordnung von 2,8 bar (40 psi) ist.

7. Vorrichtung nach Anspruch 2, wobei die den Luftstrom richtende Einrichtung (25) eine Austrittsdüse hat, die eine mit einer Luftdruckquelle verbundene Bohrung mit einer Bohrungslänge von etwa zwischen 1 und 4,8 cm (0,4 und 1,9 Inch) hat.

8. Vorrichtung nach Anspruch 7, wobei die Bohrungslänge in der Größenordnung von 2,3 cm (0,9 Inch) ist.

9. Vorrichtung nach Anspruch 7, wobei die Bohrung einen Durchmesser im Bereich von etwa 0,08 bis 0,15 cm (0,03 bis 0,06 Inch) hat.

10. Vorrichtung nach Anspruch 9, wobei der Bohrungsdurchmesser in der Größenordnung von 0,11 cm (0,042 Inch) ist.

11. Vorrichtung nach einem der Ansprüche 2 bis 10, wobei die Sensoren (27...30) elektroakustische Sensoren sind, die um den Luftstrom (25) in einer Weise angeordnet sind, um die Richtwirkung der Sensoreinrichtung (27,...30) zu verbessern, wobei jeder Sensor eine Einrichtung zum Erzeugen eines elektrischen Signals umfaßt, das den von dem Sensor empfangenen Schallwellen entspricht, und aufweist:
eine Einrichtung (53) zum Summieren des erzeugten elektrischen Signals der Sensoren (27,...30) zum Erhalten eines ersten Ausgangssignals;
eine Filtereinrichtung (58...65), die mit der Summiereinrichtung (53) zum Ausfiltern unerwünschter Frequenzen in den ersten Ausgangssignalen

der Summiereinrichtung verbunden ist;
eine Vielzahl von Bandpaßkanälen (57), die jeweils mit der Filtereinrichtung (58,...65) zum Passieren eines vorbestimmten Frequenzbandes verbunden sind, wobei die Frequenzbänder eines jeden Kanals unterschiedlich sind, und
eine Erfassungseinrichtung (70), die auf die Frequenzbänder der Kanäle anspricht, um ein erstes Erfassungssignal zu erzeugen, das eine bestimmte Eigenschaft in den Schallwellen angibt.

12. Vorrichtung nach Anspruch 11, wobei die Erfassungseinrichtung (70) außerdem eine zweite Summiereinrichtung (71) zum Summieren der Frequenzbänder der Bandpaßkanäle (57) aufweist, um ein zweites Ausgangssignal zu erhalten;
eine mit der Summiereinrichtung (71) verbundene Einrichtung (75) zum Erzeugen eines vorbestimmten Schwellenpegels und eine erste Vergleichereinrichtung (77) zum Vergleichen des Schwellenpegels mit dem zweiten Ausgangssignal von der zweiten Summiereinrichtung (71) zum Erzeugen des Erfassungssignals, wenn das zweite Ausgangssignal der zweiten Summiereinrichtung (71) einen bezüglich des Schwellenpegels vorbestimmten Wert hat.

13. Vorrichtung nach Anspruch 12, die außerdem aufweist:
eine mit der zweiten Summiereinrichtung (71) verbundene zweite Schwellenpegel-Erzeugungseinrichtung (76) zum Erzeugen eines zweiten Schwellenpegels zum Erfassen einer zweiten Eigenschaft der Schallwellen;
eine zweite Vergleichereinrichtung (77) zum Vergleichen des Ausgangssignals der zweiten Summiereinrichtung (71) mit dem zweiten Schwellenpegel zum Erzeugen eines zweiten Erfassungssignals, wenn das Ausgangssignal der zweiten Summiereinrichtung (71) bezüglich des zweiten Schwellenpegels einen bestimmten Wert hat.

14. Vorrichtung nach Anspruch 13, wobei die zweite Schwellenpegel-Erzeugungseinrichtung (76) ein Tiefpaßfilter aufweist, das einen Pegel des Ausgangssignals der zweiten Summiereinrichtung (71) extrahiert, der die zweite Eigenschaft der Schallwellen angibt, sowie eine mit dem Tiefpaßfilter verbundene Einrichtung zum Erzeugen des zweiten Schwellenpegels aufweist.

15. Vorrichtung nach Anspruch 14, die außerdem einen Zweigpfad (73c) zum Koppeln des Ausgangssignals der zweiten Summiereinrichtung (71) auf die zweite Vergleichereinrichtung (77) aufweist, wobei dieser Zweigpfad ein Anpassungsfilter (81) zum Anpassen eines Übergangsansprechens in dem Zweigpfad (73c) an ein Übergangsansprechen des Tiefpaßfilters hat.

16. Vorrichtung nach Anspruch 15, die außerdem einen zweiten Zweigpfad (73a) zum Koppeln des Ausgangssignals der zweiten Summiereinrichtung (71) auf die zweite Vergleichereinrichtung (77) aufweist,
wobei der zweite Zweigpfad (73a) ein Anpassungsfilter (80) zum Anpassen eines Übergangsansprechens des zweiten Zweigpfades auf das Übergangsansprechen des Tiefpaßfilters umfaßt.

17. Vorrichtung nach Anspruch 16, wobei der zweite Zweigpfad (73a) außerdem eine Einrichtung (78) zum Subtrahieren eines Ausgangssignals des Tiefpaßfilters von der zweiten Summiereinrichtung (71) aufweist.

18. Vorrichtung nach Anspruch 17, wobei der zweite Zweigpfad (73a) außerdem einen Halbwellengleichrichter (79) zum Hindurchlassen von Signalen nur einer Polarität und eine Einrichtung zum Umformen des gleichgerichteten Halbwellensignals in ein Gleichstromsignal aufweist.

19. Vorrichtung nach Anspruch 11, wobei der Bandpaßkanal (57) ein Bandpaßfilter (58a,...65a) aufweist, das sich von jedem benachbarten Bandpaßfilter um eine halbe Oktave unterscheidet.

20. Vorrichtung nach Anspruch 19, wobei das Bandpaßfilter (58a,...65a) eine geschaltete Kondensatorfiltereinrichtung aufweist.

21. Vorrichtung nach Anspruch 11, wobei jeder Bandpaßfilterkanal (57) eine Filtereinrichtung (58a, ...65a) zum Hindurchlassen eines vorbestimmten Frequenzbandes und eine Einrichtung (58b...65b) zum Umformen der Frequenzbänder der Filtereinrichtung in ein Gleichspannungssignal aufweist.

22. Vorrichtung nach Anspruch 21, wobei die Filtereinrichtung (58a,...65a) ein vierpoliges Chebychev-Filter aufweist.

23. Vorrichtung nach einem der vorhergehenden Ansprüche, wobei die Einrichtung (57, 70) zum Erzeugen von Signalen, die kennzeichnend für das Zusammenwirken mit den Gegenständen sind, erste ("Abstand"), zweite ("Kante"), und dritte (Papier") Zustände der Gegenstände beobachtet.

24. Verfahren zum Zählen von in einer ersten Richtung längs eines Pfades geförderten Gegenstän-

den mit den Schritten:
Richten eines Luftstroms auf die Gegenstände in einer zweiten Richtung in einem Winkel zu der ersten Richtung, um mit den individuellen Gegenständen in Folge zusammenzuwirken,
Erfassen des Zusammenwirkens des Luftstroms mit den Gegenständen durch Erfassen von Schallwellen, die sich ändernde Frequenzen und zugeordnete Amplituden haben, die durch den zusammenwirkenden Luftstrom erzeugt werden,
Erzeugen von Signalen, die kennzeichnend für das Zusammenwirken mit den Gegenständen sind, im Ansprechen auf die sich ändernden Frequenzen und zugeordneten Amplituden der erfaßten Schallwellen und
Benutzen der erzeugten Signale zum Zählen der Gegenstände;
dadurch gekennzeichnet, daß
der Luftstrom in einem schiefen Winkel zu der ersten Richtung gerichtet wird;
beim Erzeugen der Signale eine Vielzahl von Frequenzen ausgewählt wird, die den Frequenzen des erfaßten Zusammenwirkens entsprechen, mit einem Spektrumanalysierer (57), der durch das erfaßte Zusammenwirken beaufschlagt wird, und
Erzeugen eines Signals mit einer Amplitude, die sich nach Maßgabe der Amplitude der ausgewählten Frequenzen ändert.

25. Verfahren nach Anspruch 24, das außerdem den Schritt des Anordnens einer Vielzahl von Sensoren (27,...30) neben dem Pfad in Intervallen um einen imaginären Kreis, der den Luftstrom (25) umgibt, umfaßt.

26. Verfahren nach Anspruch 24 oder 25, wobei die erzeugten Signale, die kennzeichnend für das Zusammenwirken mit den Gegenständen sind, zum Zählen der Gegenstände summiert werden.

27. Verfahren nach einem der Ansprüche 24 bis 26, wobei die ausgewählten Frequenzen Schallwellen aufweisen, die eine Frequenz oberhalb von 1000 Hz haben.

28. Verfahren nach einem der Ansprüche 24 bis 27, wobei erste (Abstand"), zweite ("Kante"), und dritte (Papier") Zustände der Gegenstände beobachtet werden.

Revendications

1. Appareil pour comptage d'articles convoyés dans une première direction le long d'un chemin comprenant:
un moyen (25) pour diriger un jet d'air vers les articles dans une seconde direction (26), selon un angle tel avec la première direction, qu'il interagisse avec les articles individuels en succession;
des moyens de détection (27, 28, 29, 30) pour détecter l'interaction du jet d'air avec les articles en détectant les ondes sonores ayant des fréquences variables et des amplitudes associées générées par le jet d'air qui interagit,
un moyen (57, 70) sensible aux fréquences variables et amplitudes associées des ondes sonores détectées, pour générer des signaux caractéristiques de l'interaction avec les articles, et
un moyen de comptage (82) sensible auxdits signaux générés pour compter les articles;
caractérisé en ce que
ledit moyen de direction (25) dirige ledit jet d'air selon un angle oblique par rapport à la première direction, et ledit moyen (57, 70) sensible aux fréquences variables et amplitudes associées comprend un analyseur de spectre (57), pour sélectionner plusieurs fréquences et pour générer un signal ayant une amplitude qui varie selon l'amplitude des fréquences sélectionnées.

2. Appareil selon la revendication 1, dans lequel lesdits moyen de détection (27...30) comprennent plusieurs détecteurs placés autour dudit jet d'air (25), chaque détecteur (27...30) générant un signal de sortie ayant des caractéristiques prédéterminées qui varient selon une fréquence et une amplitude associée des ondes sonores générées.

3. Appareil selon la revendication 2, dans lequel lesdits articles sont des cahiers qui se chevauchent et qui sont espacées.

4. Appareil selon la revendication 2, dans lequel lesdits détecteurs (27...30) sont aménagés en intervalles autour d'un cercle imaginaire entourant ledit jet d'air (25).

5. Appareil selon la revendication 2, dans lequel le moyen dirigeant le jet d'air (25) comporte un moyen pour fournir une pression d'air dans une plage de 2,1 - 3,5 bas (30 - 50 psi) environ.

6. Appareil selon la revendication 5, dans lequel la pression d'air est de l'ordre de 2,8 bar (40 psi).

7. Appareil selon la revendication 2, dans lequel le moyen dirigeant le jet d'air (25) comporte une buse de sortie ayant un alésage couplé à une source d'air sous pression, et ayant une longueur d'alésage comprise entre 1 et 4,8 cm (0,4 et 1,9 pouces) environ.

8. Appareil selon la revendication 7, dans lequel la

longueur de l'alésage est de l'ordre de 2,3 cm (0,9 pouce).

9. Appareil selon la revendication 7, dans lequel ledit alésage a un diamètre situé dans la plage de 0,08 - 0,15 cm (0,03 - 0,06 pouce) environ.

10. Appareil selon la revendication 9, dans lequel le diamètre de l'alésage est de l'ordre de 0,11 cm (0,042 pouces).

11. Appareil selon l'une quelconque des revendications 2 à 10, dans lequel lesdits détecteurs (27...30) sont des détecteurs acousto-électriques aménagés autour dudit jet d'air (25) de manière à renforcer la directivité dudit moyen détecteur (27...30), chaque détecteur comportant un moyen pour générer un signal électrique correspondant auxdites ondes sonores reçues par le détecteur; et comprenant:
un moyen (53) pour sommer les signaux électriques générés par lesdits détecteurs (27...30), pour obtenir un premier signal de sortie;
des moyens de filtres (58...65) couplés audit moyen sommateur (53), pour filtrer les fréquences non-désirées dans les premiers signaux de sortie dudit moyen de sommation;
plusieurs canaux passe bande (57) couplés chacun auxdits moyens de filtres (58...65), pour laisser passer une bande de fréquences prédéterminée, les bandes de fréquences de chaque canal étant différentes, et
un moyen de détection (70) sensible aux bandes de fréquences desdits canaux, pour générer un premier signal de détection représentant une caractéristique particulière desdites ondes sonores.

12. Appareil selon la revendication 11, dans lequel ledit moyen de détection (70) comprend en outre un second moyen sommateur (71), pour sommer les bandes de fréquences desdits canaux passe bande (57), afin d'obtenir un second signal de sortie;
un moyen (75) couplé audit moyen de sommation (71), pour fournir un niveau de seuil prédéterminé, et
un premier moyen comparateur (77), pour comparer ledit niveau de seuil au second signal de sortie provenant dudit second moyen de sommation (71), pour générer ledit signal de détection lorsque le second signal de sortie dudit second moyen de sommation (71) est d'une valeur prédéterminée par rapport audit niveau de seuil.

13. Appareil selon la revendication 12, comprenant en outre
un second moyen générateur de seuil (76) couplé audit second moyen de sommation (71), pour générer un second niveau de seuil, pour détecter une seconde caractéristique dudit profil;
un second moyen comparateur (77), pour comparer la sortie dudit second moyen de sommation (71) audit second niveau de seuil, pour générer un second signal de détection, lorsque la sortie dudit second moyen de sommation (71) est d'une valeur prédéterminée par rapport audit second niveau de seuil.

14. Appareil selon la revendication 13, dans lequel ledit second moyen générateur de niveau de seuil (76) comprend un moyen de filtre passe bas qui extrait un niveau de la sortie dudit second moyen de sommation (71) représentant la seconde caractéristique desdites ondes sonores, et un moyen couplé audit moyen de filtre passe bas pour produire ledit second niveau de seuil.

15. Appareil selon la revendication 14, comprenant en outre un chemin de branche (73c) pour coupler la sortie dudit second moyen de sommation (71) audit second moyen comparateur (77), ledit chemin de branche comportant un filtre adapté (81), pour adapter une réponse transitoire dans ledit chemin de branche (73c) à une réponse transitoire dudit moyen de filtre passe bas.

16. Appareil selon la revendication 15, comprenant en outre un second chemin de branche (73a), pour coupler la sortie dudit second moyen de sommation (71) audit second moyen comparateur (77),
ledit second chemin de branche (73a) comportant un moyen de filtre adapté (80), pour adapter une réponse transitoire de ladite seconde branche à la réponse transitoire dudit moyen de filtre passe bas.

17. Appareil selon la revendication 16, dans lequel ledit second chemin de branche (73a) comprend en outre un moyen (78) pour soustraire la sortie dudit moyen de filtre passe bas dudit second moyen de sommation (71).

18. Appareil selon la revendication 17, dans lequel ledit second chemin de branche (73a) comporte en outre un moyen de redresseur simple alternance (79), pour ne laisser passer que les signaux d'une polarité, et un moyen pour convertir lesdits signaux du redresseur simple alternance en un signal continu.

19. Appareil selon la revendication 11, dans lequel chaque dit canal de filtre passe bas (57) comprend un filtre passe bande (58a...65a) différent de chaque filtre passe bande adjacent

d'une demi-octave.

20. Appareil selon la revendication 19, dans lequel lesdits moyen de filtres passe bande (58a...65a) comprennent un moyen de filtre à capacités commutées.

21. Appareil selon la revendication 11, dans lequel chaque canal de filtre passe bande (57) comprend un moyen de filtre (58a...65a) pour laisser passer une bande de fréquences prédéterminée, et des moyens (58b...65b) pour convertir lesdites bandes de fréquences dudit moyen de filtre en un signal continu.

22. Appareil selon la revendication 21, dans lequel lesdits moyens de filtre (58a...65a) comprennent un filtre de Chebychev à quatre pôles.

23. Appareil selon l'une quelconque des revendications précédentes, dans lequel lesdits moyens (57,70) pour générer des signaux caractéristiques de l'interaction avec les articles, surveillent le premier ("espace"), le deuxième ("bord"), et le troisième ("papier") états desdits articles.

24. Procédé pour comptage d'articles convoyés dans une première direction le long d'un chemin comprenant les étapes de:
direction d'un jet d'air vers les articles dans une seconde direction selon un angle tel avec la première direction qu'il interagisse avec les articles individuels en succession,
détection de l'interaction du jet d'air avec les articles, en détectant les ondes sonores ayant des fréquences variables et des amplitudes associées générées par le jet d'air qui interagit,
génération de signaux caractéristiques de l'interaction avec les articles, en réponse aux fréquences variables et amplitudes associées des ondes sonores détectées, et
utilisation desdits signaux générés pour compter lesdits articles;
caractérisé en ce que:
ladite étape de direction dirige le jet d'air selon un angle oblique par rapport à la première direction;
et ladite étape de génération comprend la sélection de plusieurs fréquences correspondant aux fréquences de l'interaction détectée, avec un analyseur de spectre (57) en fonction de ladite interaction détectée; et
génération d'un signal ayant une amplitude qui varie selon l'amplitude des fréquences sélectionnées.

25. Procédé selon la revendication 24, comportant en outre l'étape de placement de plusieurs détecteurs (27...30) adjacents au chemin en intervalles situés autour de cercles imaginaires entourant ledit jet d'air (25).

26. Procédé selon la revendication 24 ou 25, dans lequel lesdits signaux générés caractéristiques de l'interaction avec les articles sont additionnés pour compter lesdits articles.

27. Procédé selon l'une des revendications 24 à 26, dans lequel lesdites fréquences sélectionnées comprennent des ondes sonores ayant une fréquence supérieure à 1000 Hz.

28. Procédé selon l'une des revendications 24 à 27, dans lequel lesdits premier ("espace"), deuxième ("bord"), et troisième ("papier") états desdits articles sont surveillés.

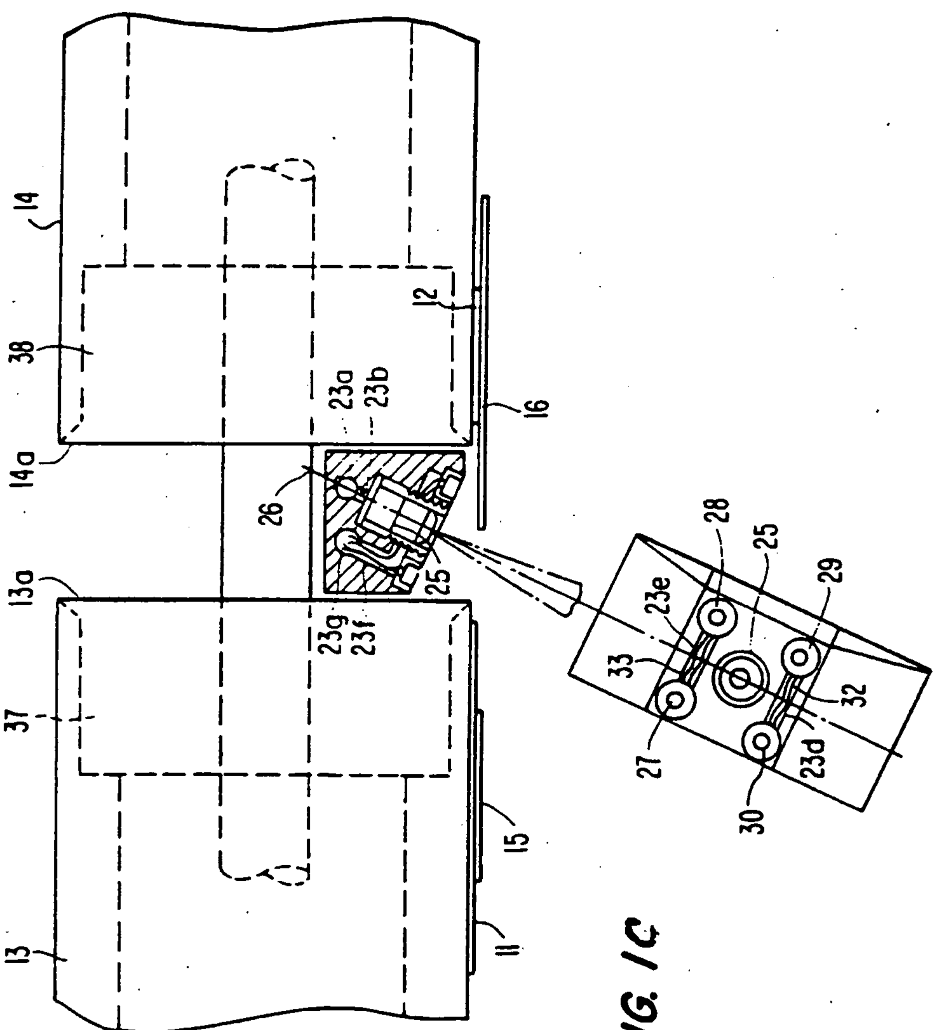

14
38
14a
13a
37
13
11
15
12
16
23a
23b
26
25
23g
23f
28
25
29
23e
33
32
27
30
23d

FIG. 1A.

FIG. 1C

FIG. 1B.

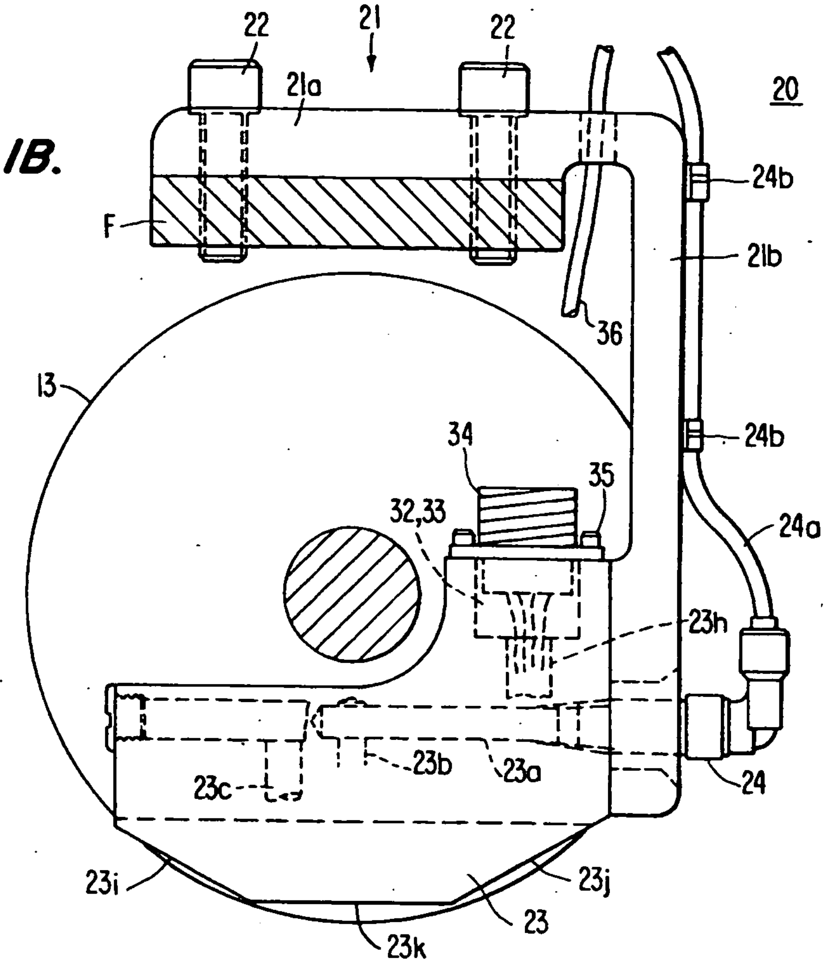

22
21
22
21a
20
24b
F
21b
36
13
24b
34
35
32,33
24a
23h
23b
23a
23c
24
23i
23j
23
23k

FIG. 2.

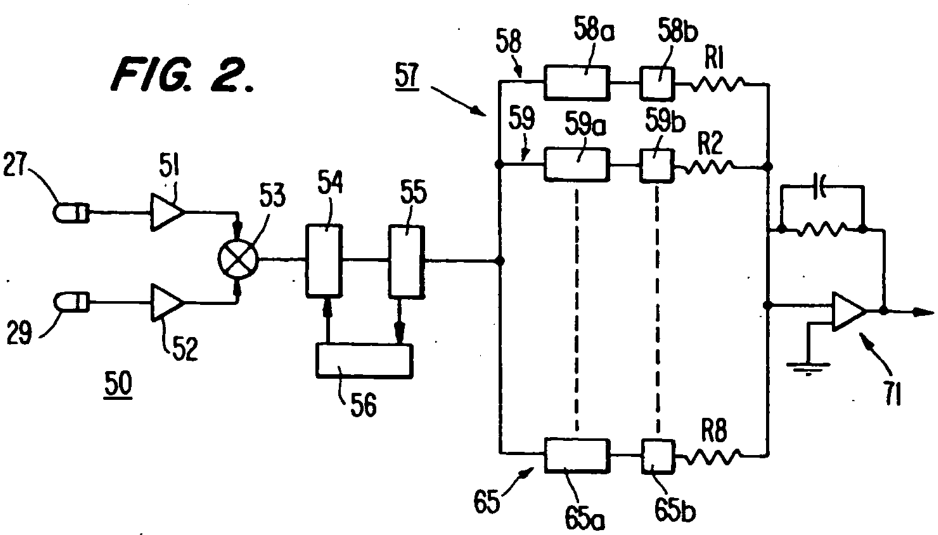
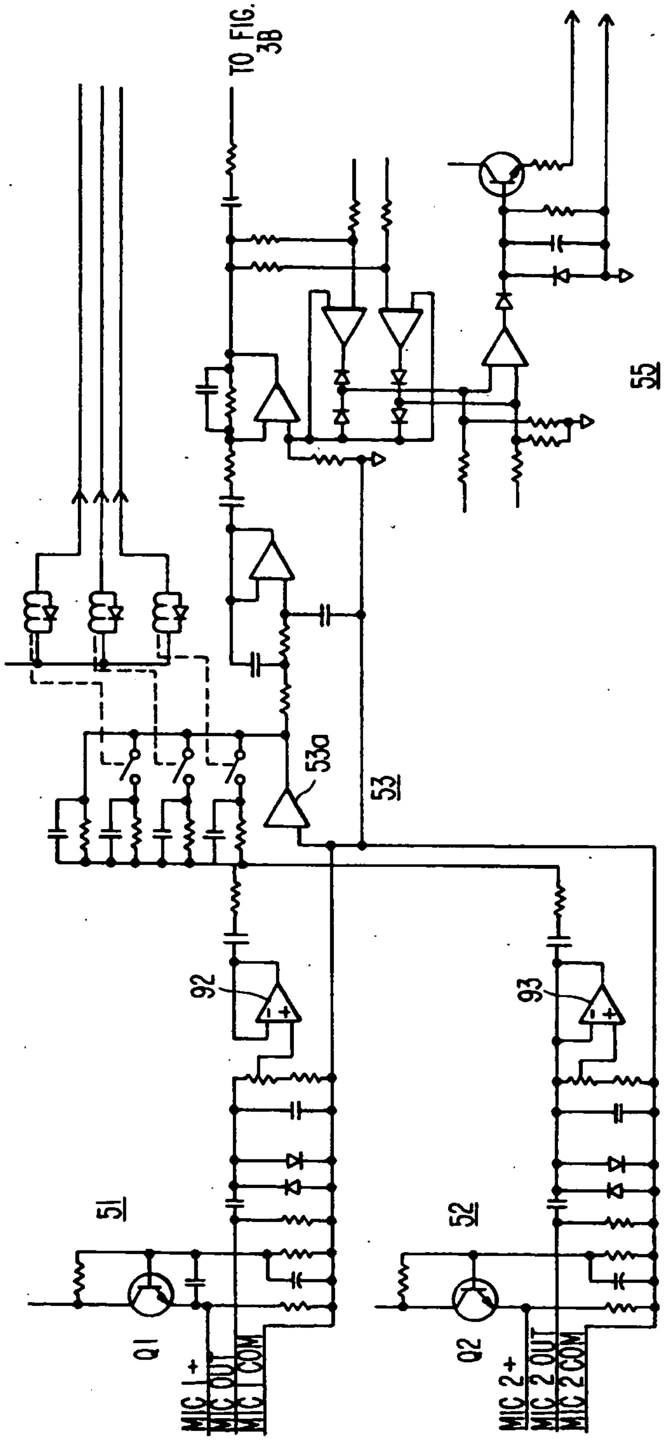
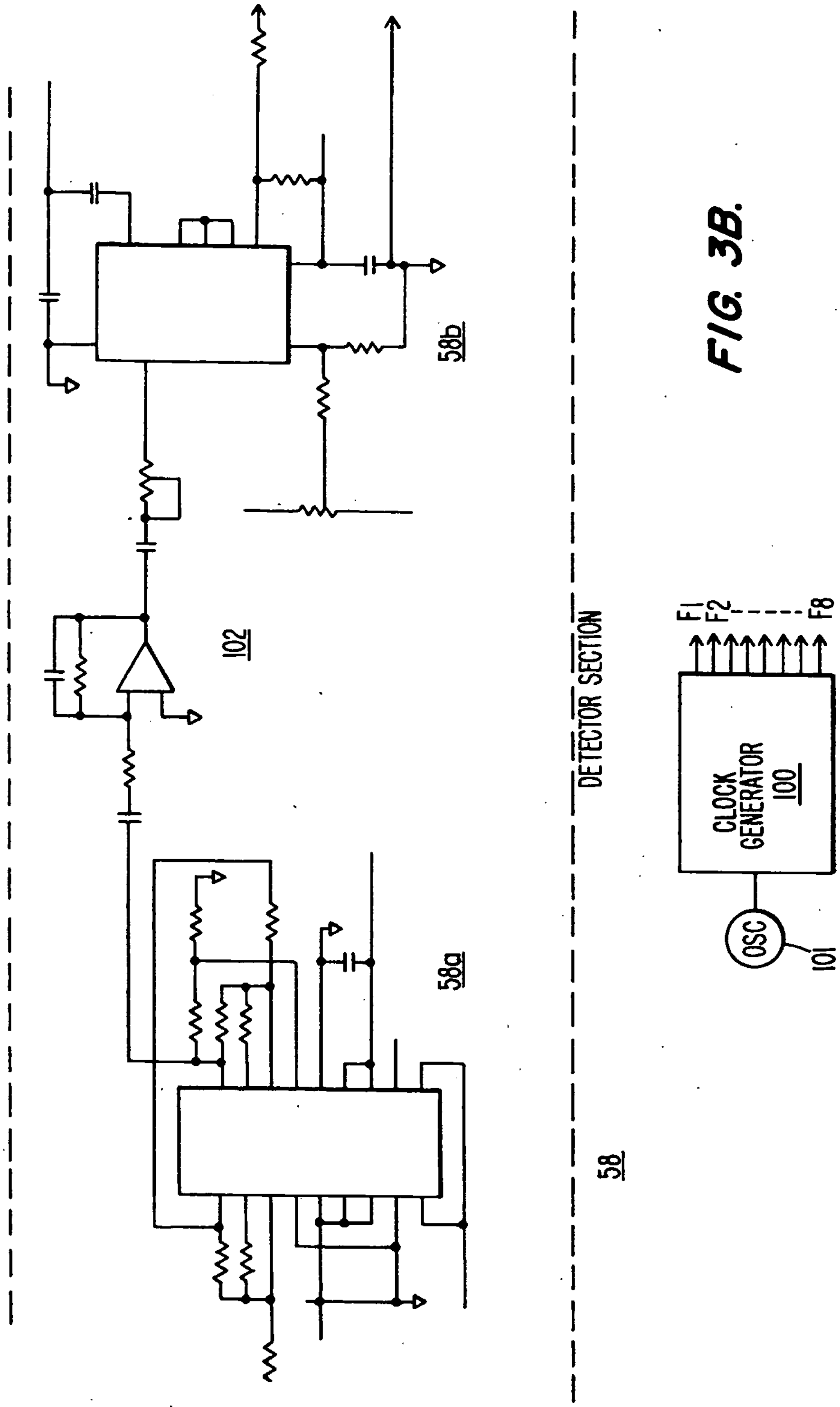

58
58a
58b
R1
57
59
59a
59b
R2
27
51
53
54
55
29
52
50
56
71
R8
65
65a
65b

FIG. 3A.


TO FIG. 3B
53a
53
55
92
93
51
52
Q1
Q2
MIC 1+
MIC OUT
MIC COM
MIC 2+
MIC 2 OUT
MIC 2 COM



58b
102
58a
DETECTOR SECTION
58
CLOCK GENERATOR 100
OSC
101
F1
F2
F8

FIG. 3B.

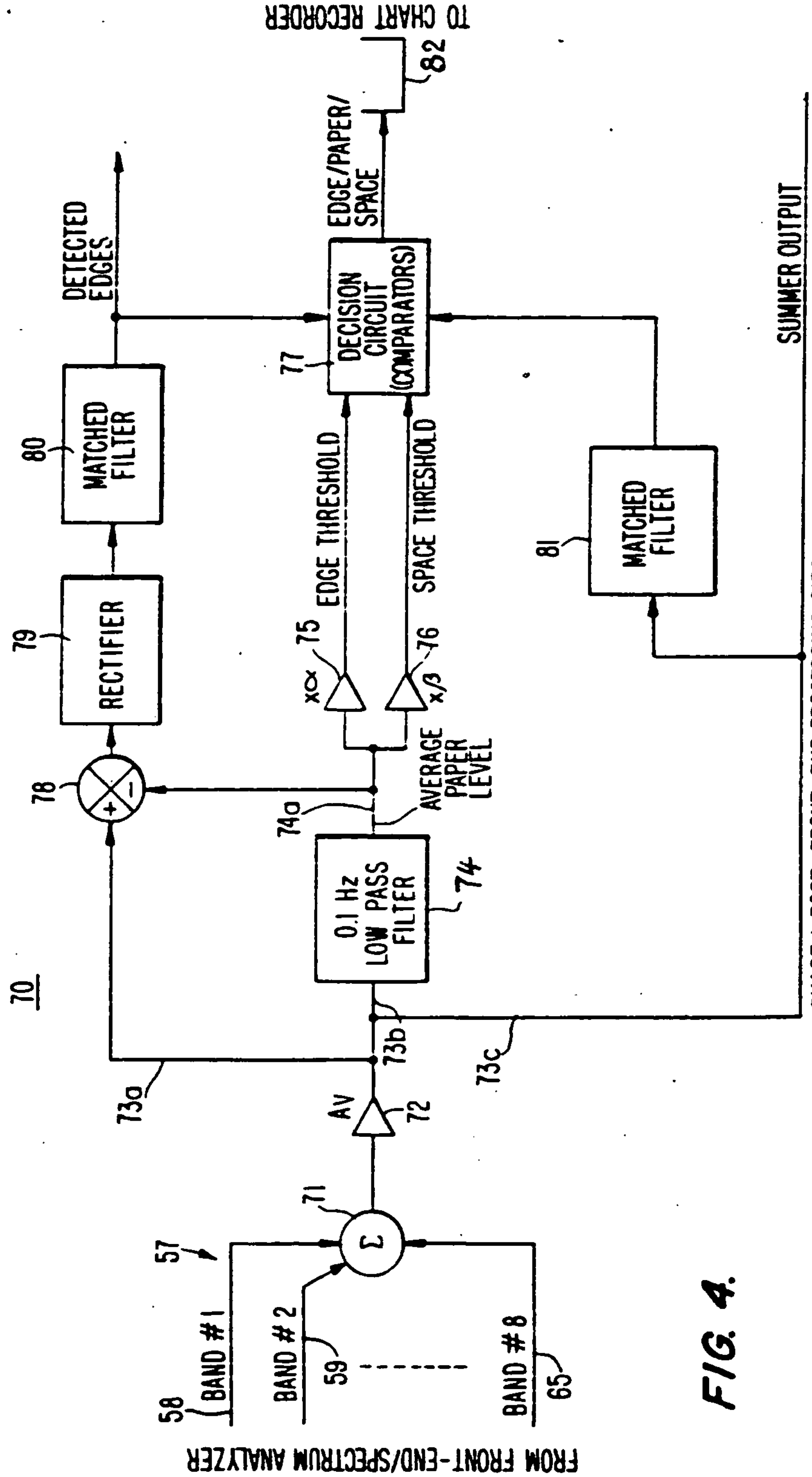

70
FROM FRONT-END/SPECTRUM ANALYZER
BAND # 1
BAND # 2
BAND # 8
58
59
65
57
71
AV
72
73a
73b
73c
0.1 Hz LOW PASS FILTER
74
74a
AVERAGE PAPER LEVEL
78
RECTIFIER
79
MATCHED FILTER
80
DETECTED EDGES
x∝
75
x/3
76
EDGE THRESHOLD
SPACE THRESHOLD
DECISION CIRCUIT (COMPARATORS)
77
EDGE/PAPER/SPACE
82
TO CHART RECORDER
MATCHED FILTER
81
SUMMER OUTPUT
PHASE I POST-FRONT-END PROCESSING CIRCUITRY - BLOCK DIAGRAM

FIG. 4.

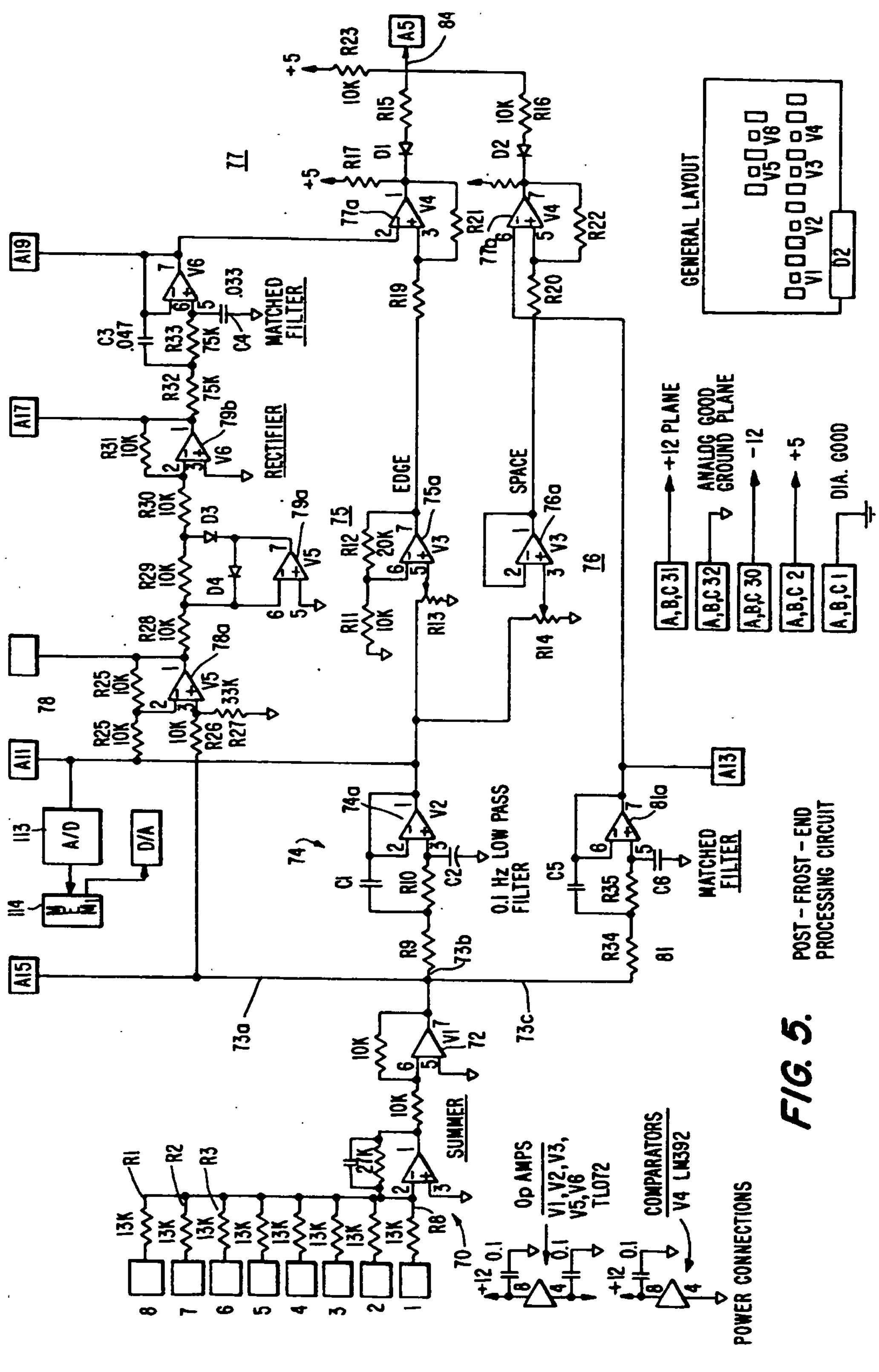
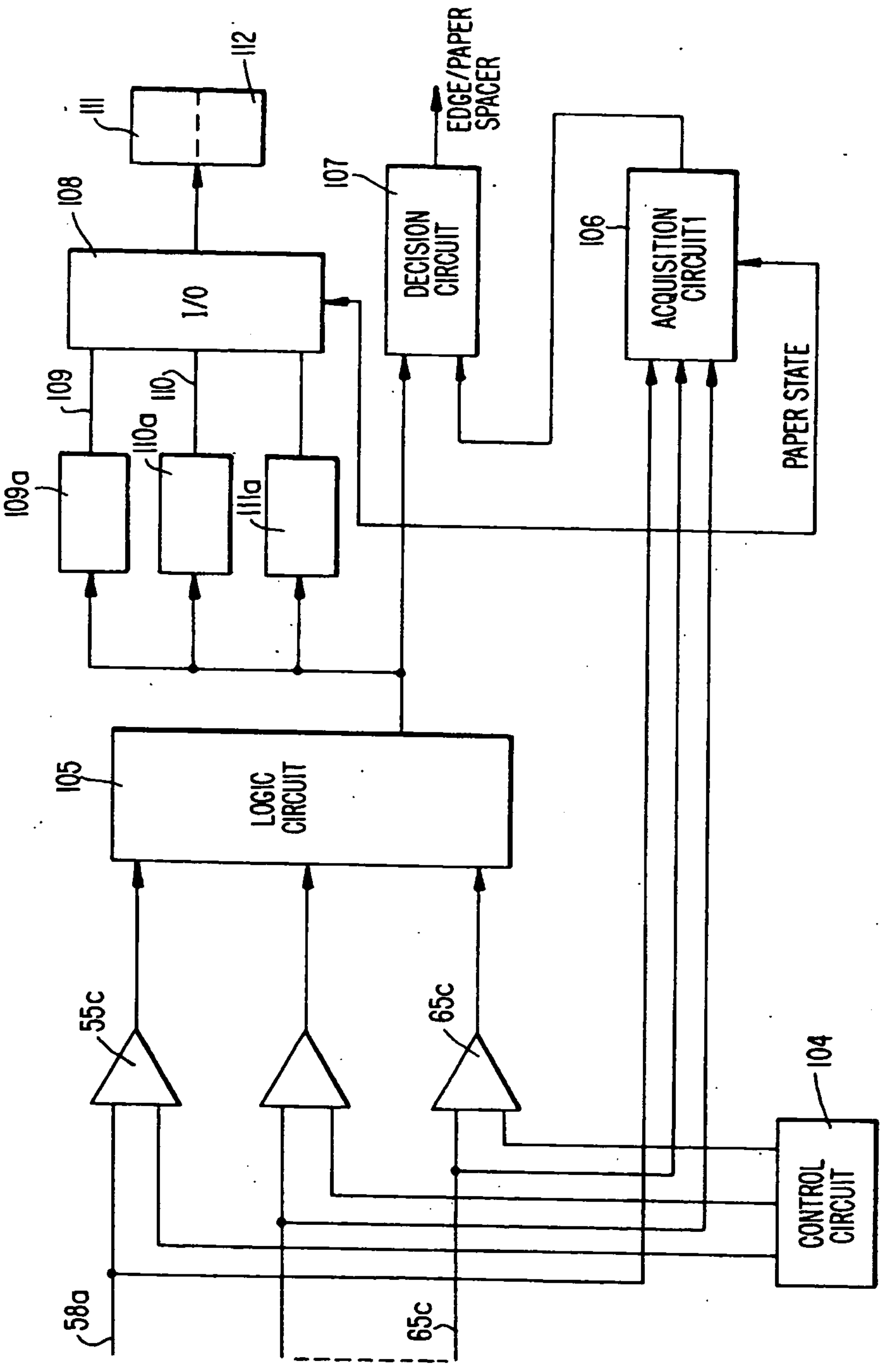


FIG. 5.

POST - FROST - END PROCESSING CIRCUIT

FIG. 6.


112
111
108
I/O
109
110
109a
110a
111a
107
DECISION CIRCUIT
EDGE/PAPER SPACER
106
ACQUISITION CIRCUIT1
PAPER STATE
105
LOGIC CIRCUIT
55c
65c
104
CONTROL CIRCUIT
58a
65c

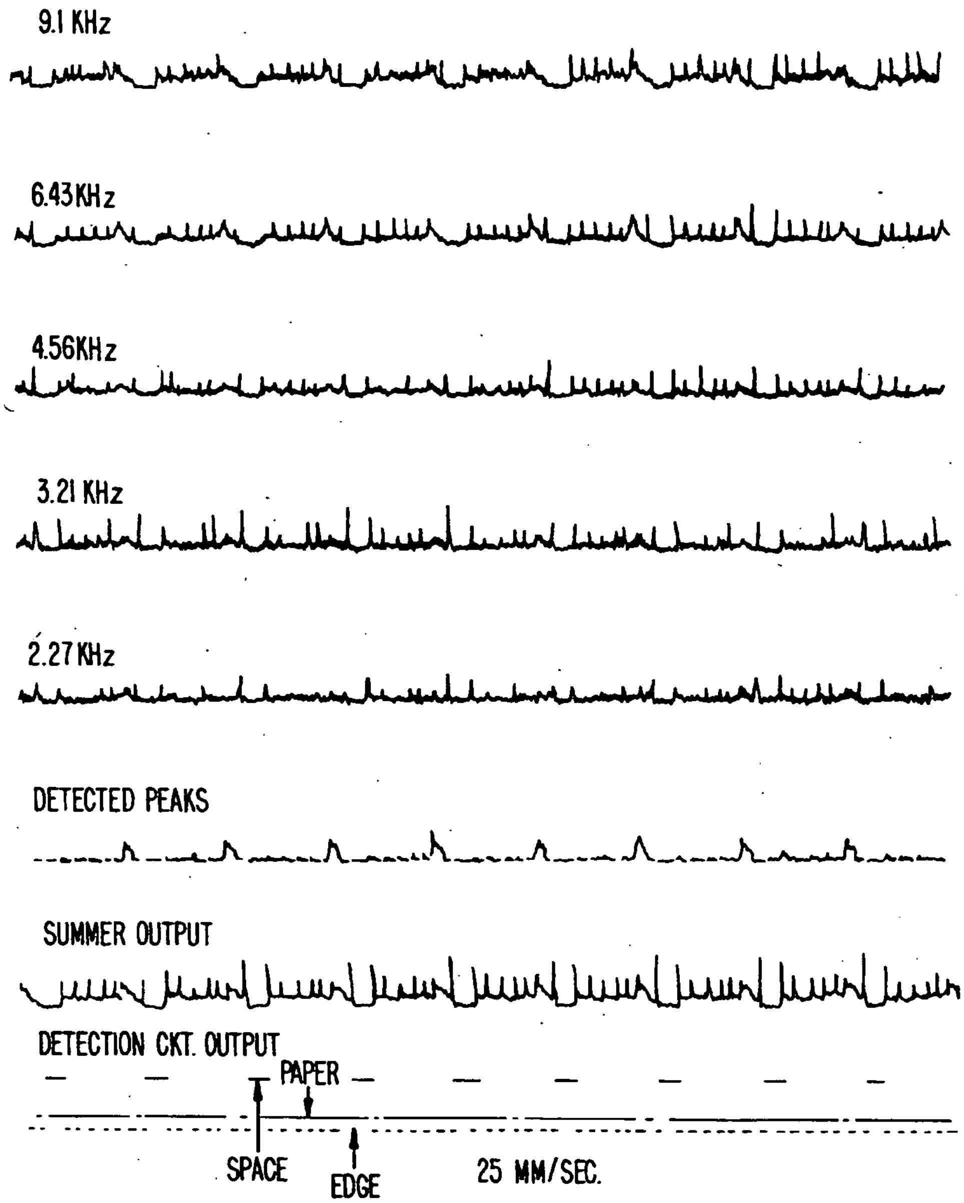


FIG. 7A.

WAVEFORMS WITH PAPER SPEED OF 144 FT./MIN.

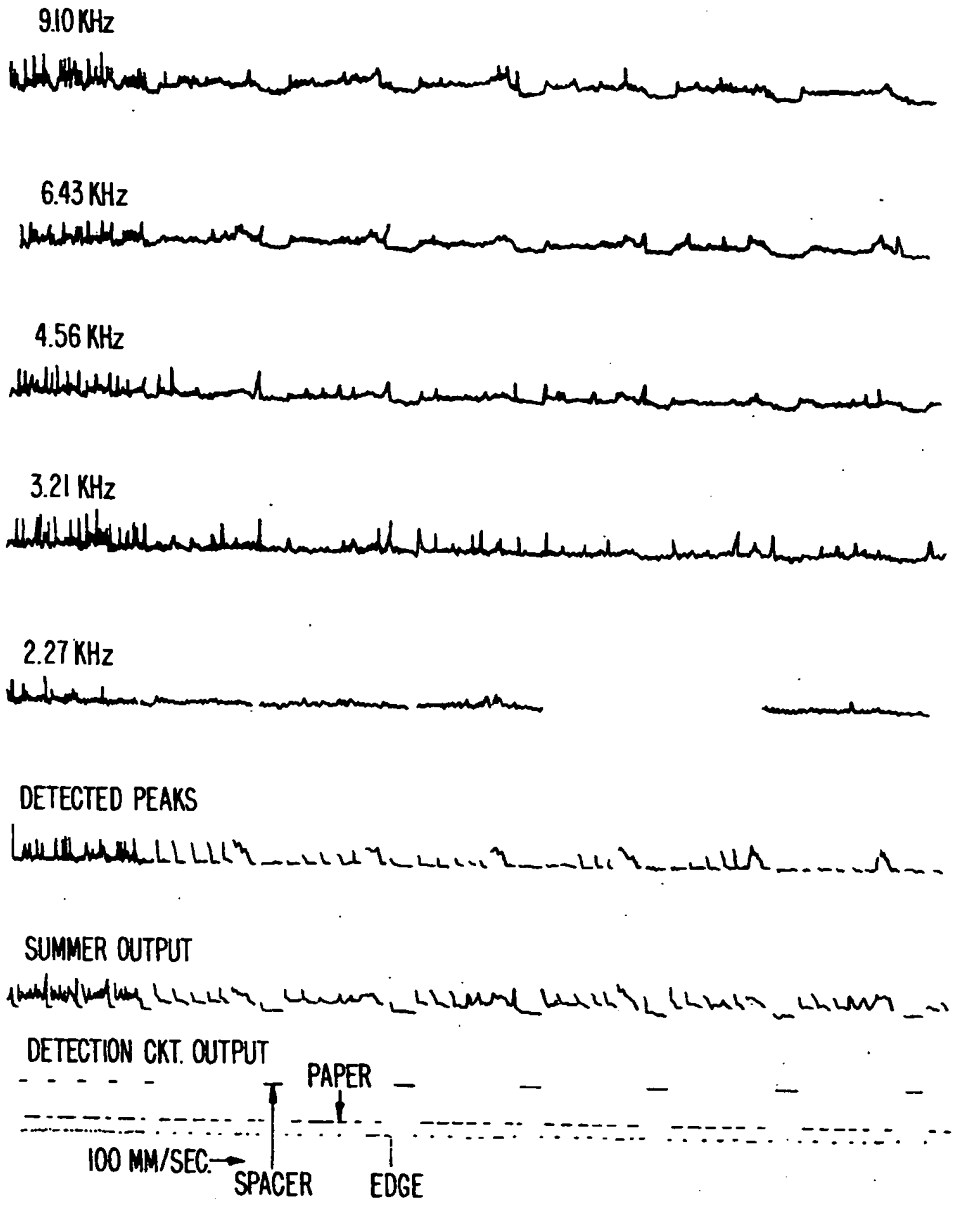


FIG. 7B.

WAVEFORM WITH PAPER SPEED OF 461 FT./MIN.

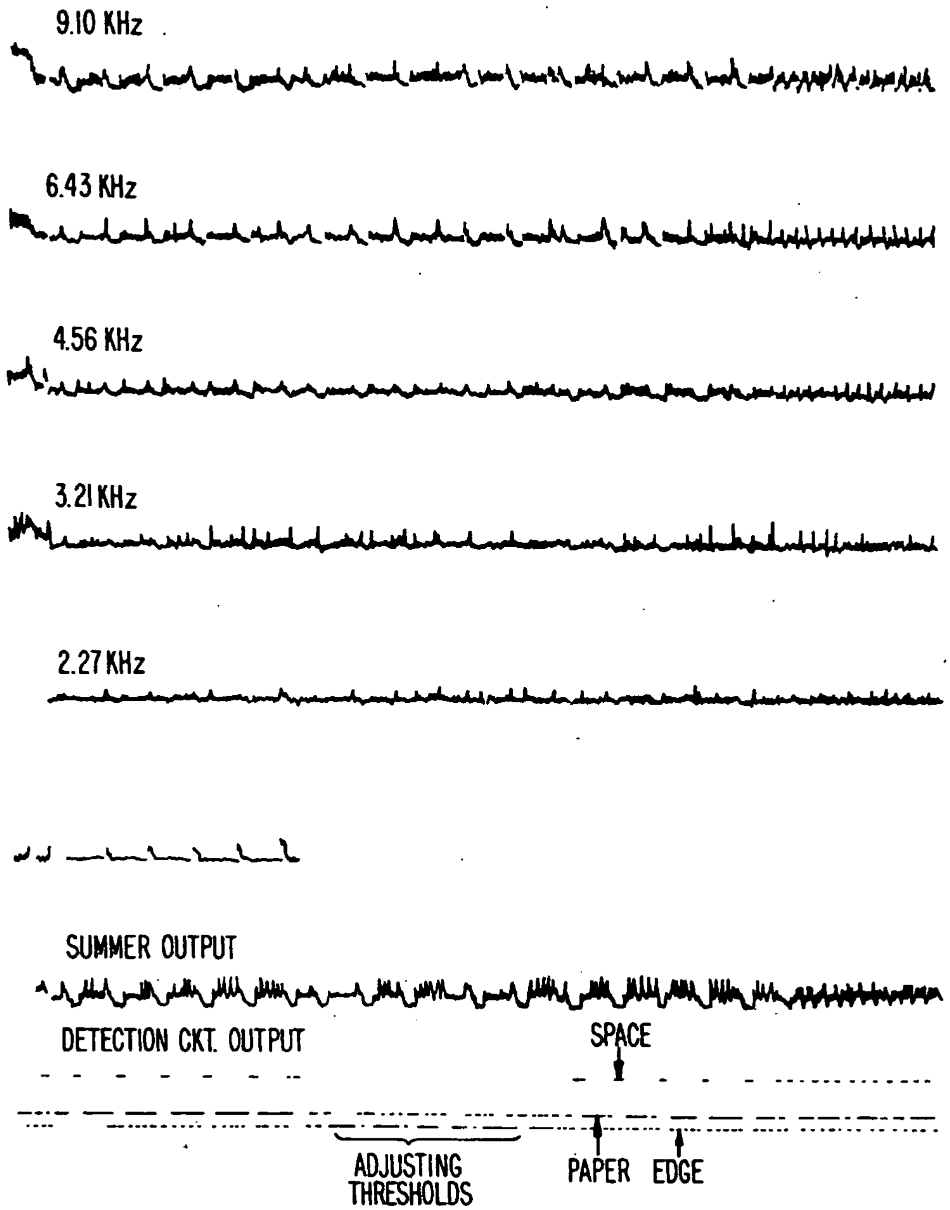


FIG. 7C.

WAVEFORM WITH EIGHT FOUR-PAGE SECTIONS (TWO SECTIONS ARE CUT AWAY TO CREATE SPACE)